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PTO/SB/05 (4/98)  
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# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.

First Inventor or Application Identifier: DEVENDRA T. BAROT

Title: COMBUSTION CHAMBER DESIGN FOR A  
QUENCH GASTIFIER

Express Mail Label No.

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages 6]  
(preferred arrangement set forth below)
  - Descriptive title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 5]
4. Oath or Declaration [Total Pages 2]
  - a. ☒ Newly executed (original or copy)
  - b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))  
(for continuation/divisional with Box 16 completed)
    - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

\* NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

## ADDRESS TO:

Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7. ☐ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement ☐ Power of Attorney  
(when there is an assignee)
9. ☐ English Translation Document (if applicable)
10. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
11. ☐ Preliminary Amendment
12. ☐ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
13. ☒ \* Small Entity Statement(s) ☐ Statement filed in prior application, Status still proper and desired (PTO/SB/09-12)
14. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. ☐ Other: .....

## 16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP)

of prior application No: \_\_\_\_\_

Prior application information: Examiner: \_\_\_\_\_

Group / Art Unit: \_\_\_\_\_

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 17. CORRESPONDENCE ADDRESS

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Signature

Devendra T. Barot

Date

01/03/2000

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**STATEMENT CLAIMING SMALL ENTITY STATUS  
(37 CFR 1.9(f) & 1.27(b))—INDEPENDENT INVENTOR**

Docket Number (Optional)

Applicant, Patentee, or Identifier: DEVENDRA T. BAROT

Application or Patent No.: \_\_\_\_\_

Filed or Issued: \_\_\_\_\_

Title: COMBUSTION CHAMBER DESIGN FOR A QUENCH GASIFIER

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

- ☒ the specification filed herewith with title as listed above.  
☐ the application identified above.  
☐ the patent identified above.

I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☒ No such person, concern, or organization exists.  
☐ Each such person, concern, or organization is listed below.

Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

DEVENDRA T. BAROT

NAME OF INVENTOR

NAME OF INVENTOR

NAME OF INVENTOR

Devendra T. Barot  
Signature of inventor

Signature of inventor

Signature of inventor

JANUARY 3, 2000

Date

Date

Date

# COMBUSTION CHAMBER DESIGN FOR A QUENCH GASIFIER

## CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This non-provisional patent application is based on a prior provisional patent application number 60/162,959 filed on November 2, 1999 by the applicant Devendra T. Barot. The following patents are cited as references in this patent application:

U.S. Patent No. 4,574,002 issued on March 4, 1986 to Barot.

U.S. Patent No. 4,828,579 issued on May 9, 1989 to Becker et al.

U.S. Patent No. 4,828,580 issued on May 9, 1989 to Dach.

U. S. Patent No. 5,464,592 issued on November 7, 1995 to Brooker et al.

## STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

"Not Applicable"

## REFERENCE TO A MICROFICHE APPENDIX

"Not Applicable"

## BACKGROUND OF THE INVENTION

U.S. Class: 48/113, 48/77, 48/74, 48/69, 48/68, 48/61, 422/207, 431/350

Quench gasifiers are used to gasify ash containing hydrocarbon feedstocks such as residual oils, waste lubrication oils, petroleum cokes and coal. A typical quench gasifier design is shown in Figure 1 (Reference: U.S. Patent No. 4,828,579). The feedstock, the oxidant and a temperature moderator (either steam or carbon dioxide) are injected into the top portion of the gasifier through a burner and are mixed with one another in the reaction zone below the burner. Steam and carbon dioxide (CO<sub>2</sub>) moderate the temperatures in the reaction zone and also act as reactants. The partial oxidation reactions that take place in this portion of the gasifier, called the combustion chamber, maintain the combustion chamber temperatures in the 2000 to 3000 °F range. The combustion chamber is lined with refractory materials such as alumina. Approximately 90.0 to 99.5 percent of the carbon in the feedstock is converted to the synthesis gases (syngas).

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The bottom portion of the quench gasifier, called the quench chamber, is separated from the combustion chamber by the floor of the combustion chamber as shown in Figure 1. The quench chamber is partially filled with water and is not lined with refractory. The quench chamber consists of three main components: the quench ring, the dip tube and the draft tube as shown in Figure 1. The main functions of the quench chamber are to cool down the synthesis gases generated in the combustion chamber by mixing them with water and to saturate the gases with water vapor.

The constricted gasifier throat area which directs the gases from the combustion chamber to the quench chamber is normally the coolest portion of the combustion chamber because of its distance from the gasifier burner and the burner flame. This area tends to be cooler than the rest of the combustion chamber also due to its proximity to the quench ring through which cooling water is injected into the quench chamber. As a result, the ash in the feedstock, which is in its molten or semi-molten form in the center portion of the combustion chamber, tends to solidify and form deposits or plugs in the throat area of the gasifier. These deposits are more likely to form with feedstocks that contain metal compounds such as vanadium trioxide ( $V_2O_3$ ) because these compounds solidify at temperatures lower than 3000 °F. In addition to causing shutdown of the gasifier, these compounds also react and damage the alumina type refractories that have been used in existing gasifiers (see U.S. Patent No. 5,464,592).

A new gasifier throat design is proposed in this invention to avoid ash deposits and plugging in the throat area of the gasifier and to avoid damage to the refractories in the throat area. The proposed design will use electrical resistor heating to achieve temperatures in the range of 3000 to 3500 °F. The new design will also use refractory materials like silicon carbide and silicon nitride that can withstand higher temperatures and larger temperature shocks than alumina. With this new design, it will be possible to increase the gasifier carbon conversion, reduce the steam (moderator) consumption and reduce the frequent damages that have been experienced to the refractories in the throat area of existing gasifiers. The proposed design will also decrease the capital cost of oil gasification plants by eliminating the need for soot recycle system downstream and will reduce the plant operating cost by improving the reliability of the gasifier operations.

#### BRIEF SUMMARY OF THE INVENTION

Electrical heating and new refractory materials are proposed for the gasifier throat area, which will increase the throat area operating temperatures without increasing oxygen consumption. The

high temperatures will improve the gasification process by increasing carbon conversion, reducing steam or CO<sub>2</sub> consumption and by eliminating ash deposits and plugging. The preferred shape for the gasifier throat with electrical heating is the wind tunnel shape proposed in the previous U.S. Patent No. 4,574,002. The gasifier throat area is heated electrically using graphite resistors to maintain temperatures in the throat area between 3000 and 3500 °F. At these temperatures, higher carbon conversion is achieved and ash deposits are melted and pushed out of the throat area by high syngas velocities achieved in the constricted throat area. The throat area refractories consist of three layers. The innermost layer or hot face that is exposed to the hot gases consists of silicon carbide or silicon nitride or a combination of the two materials. The middle layer consists of graphite resistors and the outermost layer consists of insulating refractories.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1: Prior Art Example 1, Typical Quench Gasifier Design with Conical or Funnel Shape Throat.

Figure 2: Prior Art Example 2, Typical Quench Gasifier Design with Wind Tunnel Shape Throat.

Figure 3: New Art Example, New Quench Gasifier Design with Electric Heating of the Throat Area.

Figure 4: Details of the New Throat Design

Figure 5: New Combination Quench Gasifier

#### DETAILED DESCRIPTION OF THE INVENTION

A previous patent (U.S. Patent Number 4,574,002) suggests changing the shape of the gasifier throat to avoid ash deposits and plugs in this area. The wind tunnel shape proposed in U.S. Patent No. 4,574,002 is shown in Figure 2. This shape provides a better chance of avoiding deposits and plugs in the throat area than the shape shown in Figure 1. However, the wind tunnel shape is also susceptible to deposits and plugs particularly when feedstock contains metals or metal compounds that solidify at temperatures lower than 3000 °F due to the distance of the throat from the burner and its proximity to the quench ring component of the gasifier.



In order to avoid ash deposits and plugs in the throat area, particularly with feedstocks that contain vanadium trioxide type metal compounds, it is necessary to maintain temperatures in the throat area in the 3000 to 3500 °F. At these higher temperatures, vanadium oxide type compounds (vanadium trioxide and all other metal compounds that melt and flow easily at temperatures in the 3000 to 3500 °F range) will melt and easily flow out of the throat and into the quench chamber. The throat refractory will have to withstand these high temperatures. Alumina type refractories that have been used in the throat area in the past are frequently damaged by vanadium oxide type compounds (see U.S. Patent No. 5,464,592).

This patent application proposes electrical heating (either with resistors or with electromagnetic waves) of the throat area to avoid low temperatures in the throat area. This patent application also proposes that the hot face of the throat area refractory be silicon carbide, silicon nitride or a combination of the two. As shown in Figure 4, the electrical heating elements will be made of graphite and graphite heating elements will be used behind the hot face material. The outermost layer of the throat block will be made of insulating refractory. This insulating refractory will prevent high temperature exposure of the combustion chamber floor and the quench ring.

This new design will make it possible to control temperatures in any desired range in the throat area up to an upper temperature limit of about 3500 °F. The design proposed in Figure 3 shows an approximate wind tunnel shape. The throat does not have to be exactly in the wind tunnel shape. The essential features of this design are that the ratio  $D1/D3$  be in the range of 3 to 6 and that the diameter of the throat shape should decrease as you move away from  $D1$  portion of the throat.

Figure 3 only shows an application for the electrical heating concept in the throat area of a vertical quench gasifier. In fact, this concept can also be applied to a horizontal reactor as shown in Figure 5 or to the entire hot face of the combustion chamber. This concept can also be applied to any extension of the gasifier exit area such as the transition block area of Figure 5.

Figure 5 shows a combination quench gasifier. A portion of the syngas generated in the combustion chamber is quenched in water and the remaining syngas is quenched (cooled down) by injecting a cold quench gas.

## CLAIMS

The new combustion chamber throat design, shown in Figure 3 and Figure 4, will be more successful in preventing plugging in the throat area (Claim 1). This design will also eliminate the frequent damages that have occurred to the throat refractory (Claim 2), because silicon carbide and silicon nitride can withstand higher temperatures and the erosive and corrosive effects of vanadium oxide type compounds better than alumina.

This patent suggestion also proposes eliminating the plenum chamber area shown in Figure 2. The quench ring area of the traditional quench gasifier is prone to frequent damage (References: U.S. Patent No. 4,828,580 and Patent No. 4,828,579). This new design (shown in Figure 3) will be more successful in preventing damage to the quench ring than the designs shown in Figures 1 and 2 (Claim 3), because the distance between the throat opening and the quench ring is longer in the new design. Overall, this new design will improve the gasifier on-stream time (reliability of operations) and thereby lower the gasifier operating cost (Claim 4).

The high temperatures obtained by electrical heating in the throat area will also increase the gasification reaction rates and thereby increase the carbon conversion of the gasifier by 0.1 to 3.0 percent (Claim 5). This in turn will increase the syngas production of the gasifier without increasing either oxygen consumption or feedstock consumption (Claim 6).

The use of electrical heating and silicon carbide type refractories in the throat area will also reduce the consumption of the steam as a temperature moderator (Claim 7), because it will not be necessary to moderate the temperatures. Normally approximately 0.25 to 0.35 pound of steam is required for gasification of every 1.0 pound of residual oil or coke or coal. With this new design, the steam requirement will drop to 0.15 to 0.25 pound of steam per pound of feedstock.

Due to the increased carbon conversion achieved with this design, it will be possible to eliminate the soot recovery and soot recycle system that is normally employed downstream of the gasifier. Thus electrical heating of the throat area will reduce the gasification plant capital cost (Claim 8). The concept of electrical heating of the refractory can be extended to the entire gasifier hot face. If the entire hot face of the gasifier (not just the throat area) is electrically heated, it will be possible to preheat and cure the gasifier refractories electrically. There will be no need for using a preheat burner, a flue gas cooler and an aspirator (steam ejector) for preheating refractories. This will reduce the gasification plant capital cost further (Claim 9).

## ABSTRACT

A new combustion chamber design for a quench gasifier. Electrical heating is used in the throat area of the combustion chamber to achieve temperatures up to 3500 °F to melt ash deposits and to increase carbon conversion (reduce soot production). Silicon carbide and/or silicon nitride refractory materials are used in the hot face of the throat to withstand high temperatures and high temperature shocks. The proposed design reduces the capital cost of a gasification plant by eliminating the need for soot recovery and recycle system. This design also reduces the operating cost of the gasification plant by decreasing the frequent refractory damages that have been experienced in the throat area of the existing quench gasifiers.



Figure 1  
Prior Art Example 1, Typical Quench Gasifier Design with  
Conical or Funnel Shape Throat

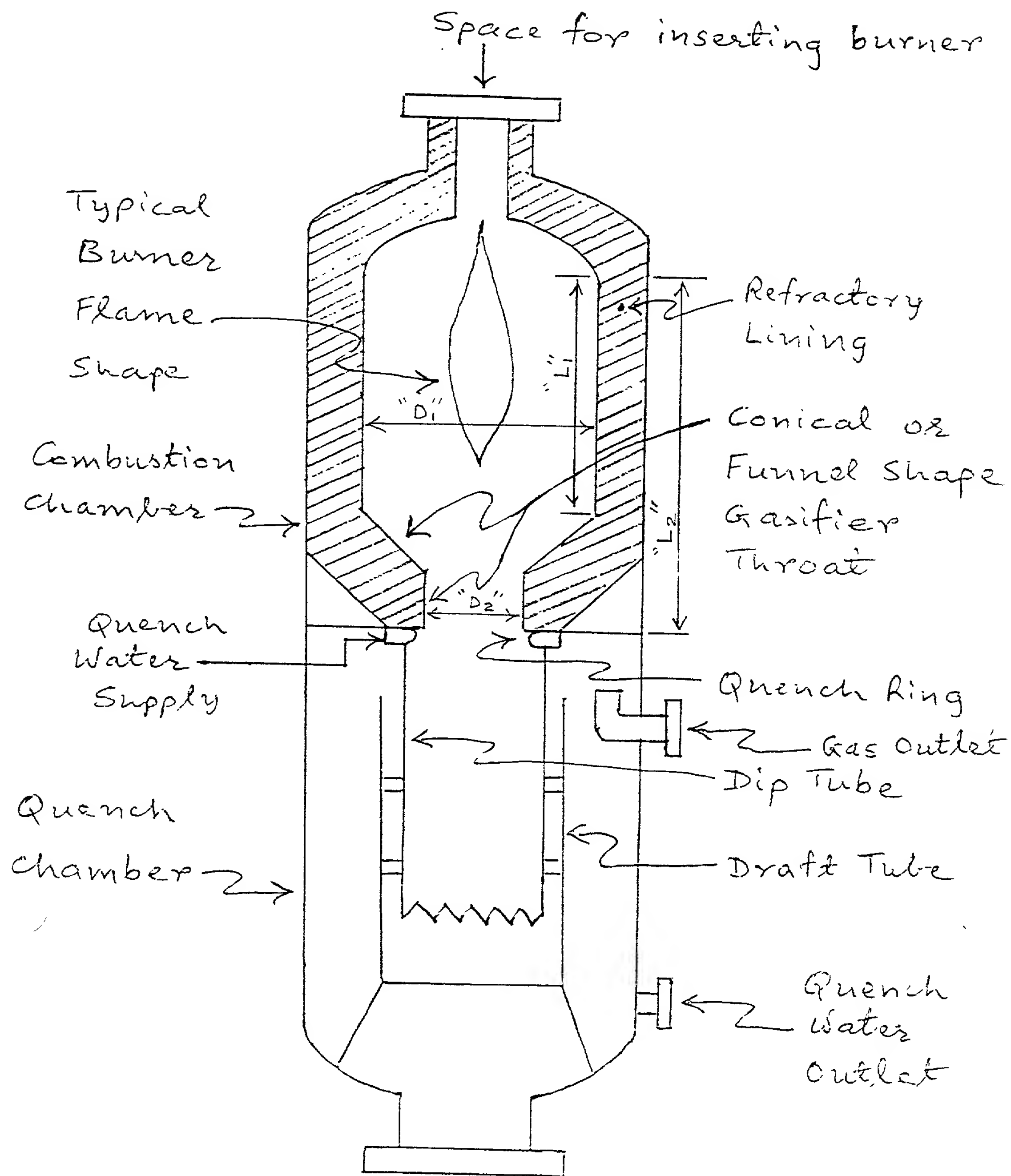


Figure 2  
Prior Art Example 2, Typical Quench Gasifier Design with  
Wind Tunnel Shape Throat

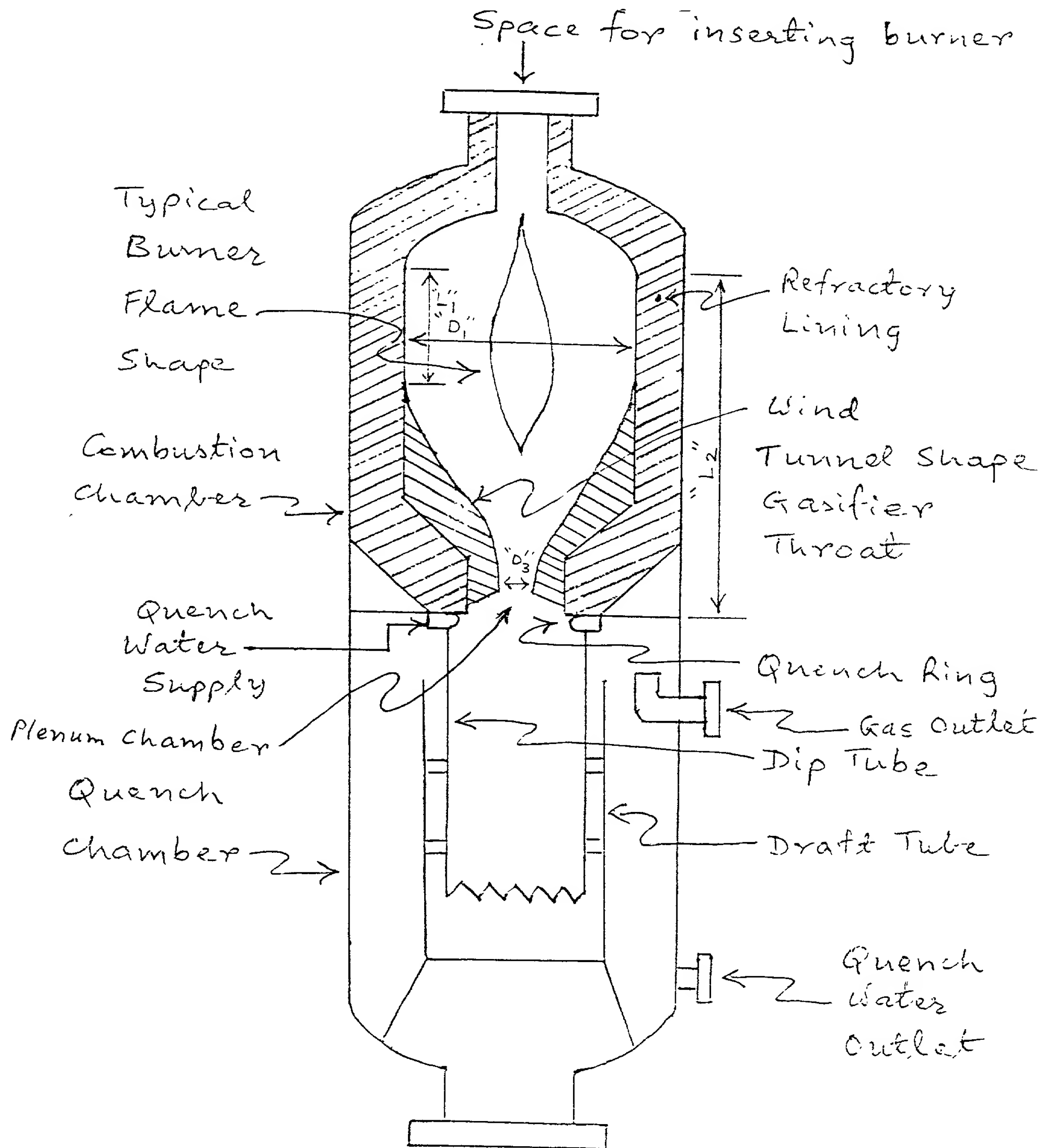


Figure 3  
New Art Example, New Quench Gasifier Design with  
Electrical Heating of the Throat Area

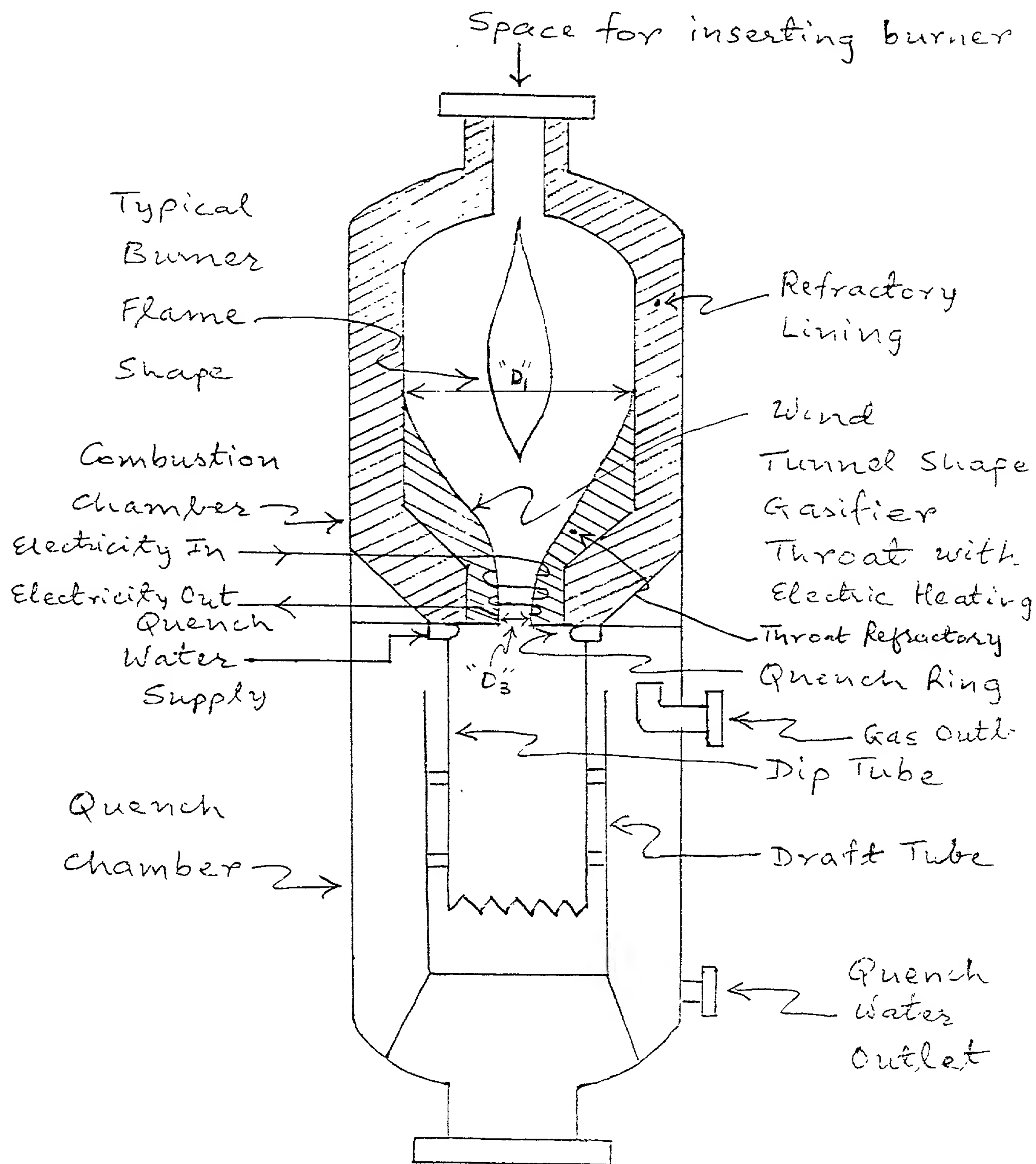
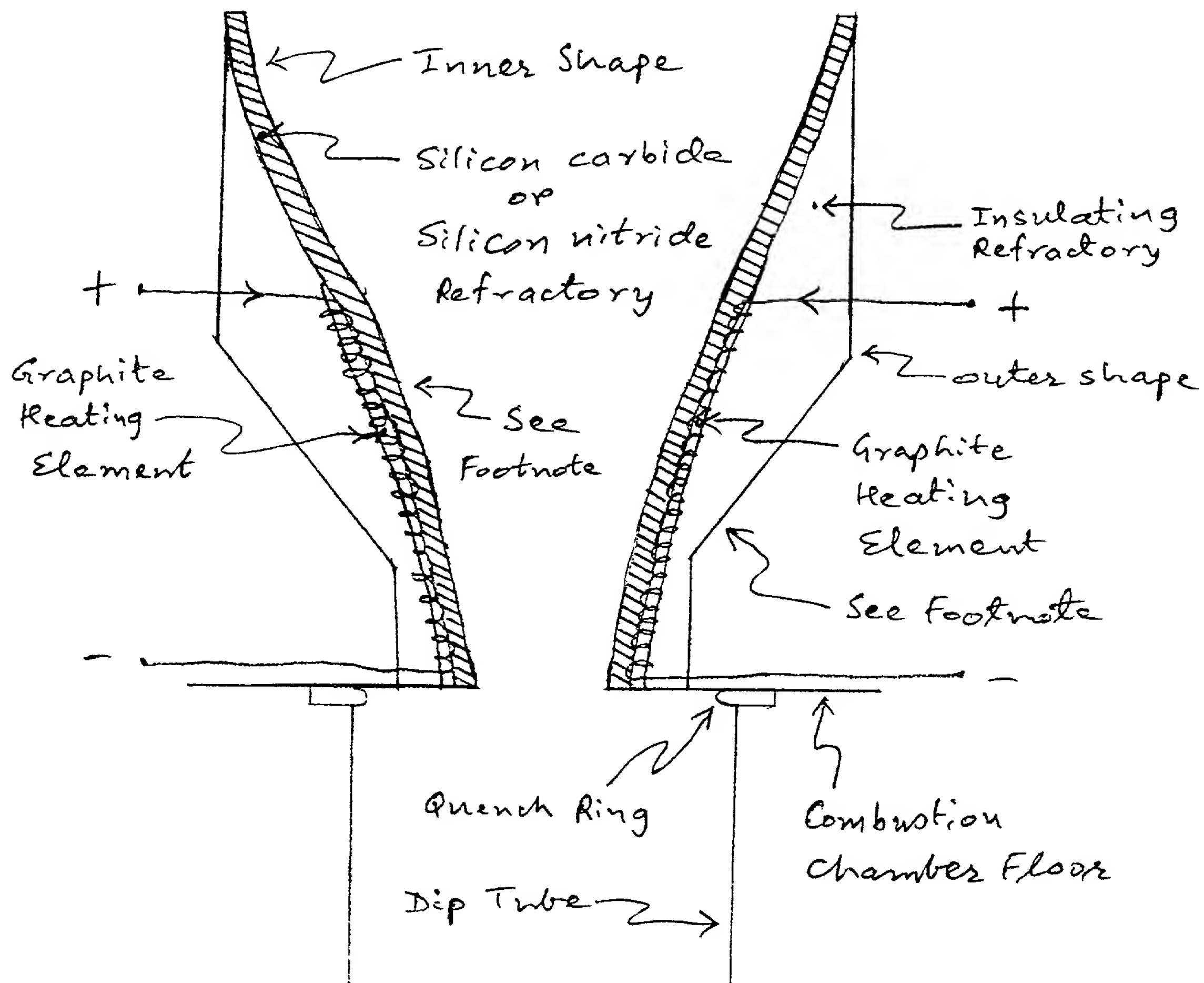
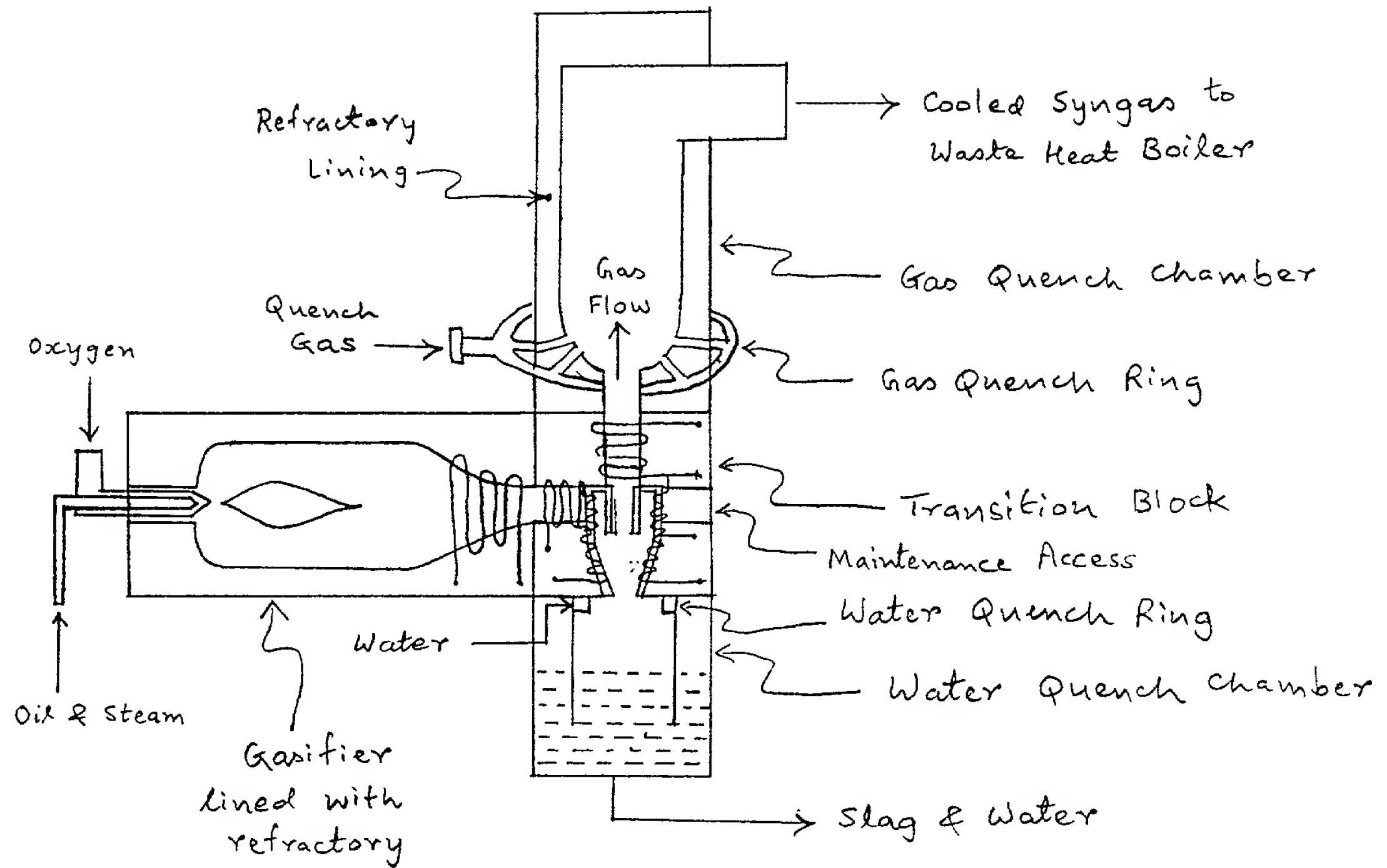


Figure 4  
Details of the New Throat Design



Note: It is the inner shape of the throat that is important. The outer shape of the throat is not important.

**Figure 5**  
**New Combination Quench Gasifier**



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**DECLARATION FOR UTILITY OR  
DESIGN  
PATENT APPLICATION  
(37 CFR 1.63)**

☒ Declaration Submitted with Initial Filing **OR** ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number

First Named Inventor

DEVENDRA T. BAROT

**COMPLETE IF KNOWN**

Application Number

/

Filing Date

Group Art Unit

Examiner Name

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

COMBUSTION CHAMBER DESIGN FOR A QUENCH GASIFIER

the specification of which

(Title of the Invention)

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY)

as United States Application Number or PCT International

Application Number

and was amended on (MM/DD/YYYY)

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
				YES	NO
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.
60/162,959	November 2, 1999	

[Page 1 of 2]

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## DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:

☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])		Family Name or Surname					
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City	Sugar Land	State	Texas	ZIP	77479	Country	U.S.A

☐ Additional inventors are being named on the \_\_\_\_\_ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto